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March 3, 1947

To: P. N. Ammend, Chief of Bureau

From: E. F. Knipling, In Charge, Division of Insects
Affecting Man and Animals

Subject: Proposed Research Project on Attractants for the Screwworm

We are submitting for your consideration a proposed research project on the screwworm. For many years I have felt that we must approach the screwworm problem from the standpoint of controlling the over-all fly population for it is doubtful in my mind if we can solve the problem to the satisfaction of ranchmen by following the lines of research that have been undertaken during the past ten years. I do not mean to infer that research on the screwworm during this period has been unproductive. On the contrary, I believe the development of Smear 62 (and modifications of this formula) represents an outstanding achievement. Under present conditions stockmen would feel the losses due to screwworms to a much greater extent if Smear 62 were not available.

I am convinced, however, that wound treatments alone will not solve the screwworm problem. For this reason I have been hopeful that we could undertake research along the lines suggested on regular appropriations. However, under present circumstances this is not possible and the outlook for the future does not seem to offer much encouragement. We have a number of urgent problems in connection with our program in the animal pest field and only a small portion of available funds can be devoted to research on the screwworm. Our present efforts on the problem will be directed towards the improvement of wound treatments since Smear 62 as well as MQ-62 have a number of shortcomings that should be corrected.

Most of us who have conducted research on the screwworm are aware of the powerful attractant factors in the wounds of animals. It has been stated frequently that this might offer a solution to the screwworm problem if we knew what the attractant principles were and if they could be produced in quantity. I personally am confident that investigations on attractants would have good chances of proving fruitful. In my opinion, however, our Division does not have personnel with the type of training needed to undertake thorough investigations on a fundamental and no doubt complex problem of this nature. I believe that a research team composed of an entomologist, biochemist, and bacteriologist should undertake such investigations.

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After our brief informal discussion several days ago, it occurred to me that a research project of the nature proposed might be given favorable consideration for support by the Bankhead-Jones Special Research Fund. We have therefore, prepared a broad general statement together with an estimate of funds requested to carry out the investigations on screwworm attractants.

I shall be glad to discuss this with you in greater detail and provide additional information if you believe the problem has sufficient merit to pass on for formal consideration by the committee which recommends allocation of Bankhead-Jones Research Funds.

E. F. Snippling

Enclosure

cc: E. W. Laake

A STATEMENT OF THE PROBLEM AND PROPOSED FUNDAMENTAL
INVESTIGATIONS ON ATTRACTANTS FOR THE SCREWORM FLY

Perspective

The screwworm (Cochliomyia americana C. & P.) is without doubt the most serious pest of livestock in the United States in areas where it is prevalent. It attacks all classes of livestock and wild mammals and even occasionally infests man. From the standpoint of monetary losses it is not considered as important to livestock interests as are certain other parasites. This fortunately is due to the fact that its range is normally restricted to a relatively small portion of the United States. During recent years, however, the screwworm has become more widely distributed, and almost every year isolated outbreaks occur in various sections of the United States outside of its former range. Increased speed in transporting livestock is believed the principal reason for this situation. In 1933 or 1934 the screwworm became established in Florida and is now considered the major livestock pest of the Southeast. During the winter it is restricted to peninsula Florida but in the summer each year it spreads to Alabama, Georgia, South Carolina, and in some years ranges into Mississippi, Tennessee, and North Carolina. In the Southwest the parasite during the winter is restricted to southern portions of Texas, Arizona and California. During the summer it extends its range in these states and usually invades Oklahoma, Kansas, Louisiana, Missouri, Arkansas, Colorado, and New Mexico. Some years rather severe local outbreaks occur as far north as, Iowa, Illinois, and Nebraska, and the species has been reported as far north and west as Wyoming and Montana. Prior to 1933 the screwworm was not known to have occurred as far north as Iowa. Since that year, however, it has been in that state and other midwestern states on several occasions.

The screwworm is a true parasite in that it breeds and develops only in living animals. Wounds of any kind on warm blooded animals are subject to infestation and the gravid fly deposits a mass of several hundred eggs thereon. The larvae hatch and feed on the living flesh and mature in about five days. Once infested, the wound becomes more attractive and other gravid females deposit eggs, resulting in a progressive increase in the number of larvae in the wound. It is safe to say that once an animal becomes infested in areas where screwworms are numerous it is doomed to destruction unless treated, whether it be a rodent or a cow.

Most of the research during the past has been concentrated on insecticides and as a result efficient wound treatments have been developed. (Smear 62 and recently EQ Smear 82.) These remedies have been welcomed by stockmen and are widely employed. Animal wounds which are treated will generally heal without becoming infested.

A STATEMENT OF THE PROGRESS AND PROSPECTS OF THE INVESTIGATION ON THE LIVERFLUKE OF THE CATTLE

Introduction

The liverfluke (*Fasciola hepatica* L., 1758) is without doubt the most serious pest of livestock in the United States in areas where it is prevalent. It attacks all classes of livestock and wild mammals and even occasionally insects and birds. From the standpoint of monetary losses it is not considered as important to livestock interests as are certain other parasites. This is particularly true in the case of the United States where it is normally restricted to a relatively small portion of the United States. During recent years, however, the liverfluke has become more widely distributed, and almost every year isolated outbreaks occur in various sections of the United States outside of its former range. Increased speed in transporting livestock is believed the principal reason for this situation. In 1933 or 1934 the liverfluke became established in Florida and is now considered the major livestock pest of the Southeast. During the winter it is restricted to peninsular Florida but in the summer it ranges into Mississippi, Tennessee, and Georgia, and in some years ranges into Mississippi, Tennessee, and North Carolina. In the Southwest the parasite during the winter is restricted to southern portions of Texas, Arizona and California. During the summer it extends the range in these states and usually includes Oklahoma, Kansas, Louisiana, Missouri, Arkansas, Colorado, and New Mexico. Some years rather severe local outbreaks occur as far north as Iowa, Illinois, and Nebraska, and the species has been reported as far north and west as Wyoming and Montana. Prior to 1933 the liverfluke was not known to have occurred as far north as Iowa. Since that year, however, it has been in that state and other midwestern states on several occasions.

The liverfluke is a true parasite in that it breeds and develops only in living animals. Females of any kind on warm blooded animals are subject to infestation and the gravid fly deposits a mass of several hundred eggs thereon. The larvae hatch and feed on the living flesh and mature in about five days. Once infested, the wound becomes more attractive and other gravid female deposit eggs, resulting in a progressive increase in the number of larvae in the wound. It is safe to say that once an animal becomes infested in areas where liverflukes are numerous it is doomed to destruction unless treated, whether it be a rodent or a cow.

Most of the research during the past has been concentrated on insecticides and as a result efficient control measures have been developed. (Smead 33 and recently 35, 36.) These remedies have been welcomed by stockmen and are widely employed. Animals which are treated will generally heal without becoming infested.

Larval infestations already present are destroyed quickly and if retreated twice a week the wounds will heal without becoming reinfested.

In addition to the development of efficient wound treatments, studies on the predisposing causes of wounds and seasonal incidence of flies have made it possible to suggest certain ranch management procedures which, if followed by livestock men, will materially reduce losses.

Limitations of Present Methods of Control and the Need for a New Approach to the Problem.

Research along lines discussed is being continued because further improvements in screwworm wound treatments are considered desirable. Further contributions to the control of the screwworm also can be made by gathering more information on the seasonal abundance and range of screwworms and, on the basis of such data, suggesting ranch management practices that will alleviate the losses caused by the parasite. However, it is evident that present measures will not solve the screwworm situation to a degree that the problem should be solved, and it is important to consider new approaches to the problem. The limitations of present methods of control as they appear at present should be briefly stated: In much of the area where screwworms occur, domestic animals are not under close supervision of the livestock owners and it is impractical to round up the animals at regular intervals. Even though most ranchers employ riders to look after the animals throughout the fly season, many infested animals escape detection. Animals infested with screwworms will seek hiding places and in brushy areas it is virtually impossible to locate all of them. Furthermore, wild hosts such as deer, rabbits, wild hogs, and other animals are constant reservoirs for the parasite. Such infestations serve to maintain a high population of flies.

Thus, it is apparent that a high degree of control for screwworms cannot be expected utilizing present methods of control. Without legislation to force frequent and regular inspection of livestock subject to screwworm attack there is little likelihood that major advances can be made by restricting our efforts to present lines of research. An over-all reduction of the incidence of infestations among domestic and wild animals not under control by livestock men is necessary. It is felt that some effective and practical method of reducing the screwworm population in nature seems to offer the only possibility of reducing this incidence.

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Limitations of Present Methods of Control and the Need for a New Approach to the Problem.

Research along lines discussed is being continued because further
improvements in worming and treatment are considered feasible.
Further contributions to the control of the worming also can be made
by gathering more information on the seasonal abundance and range of
worms and, on the basis of such data, suggesting ranch management
practices that will alleviate the losses caused by the parasite. How-
ever, it is evident that present measures will not solve the worming
situation to a degree that the problem should be solved, and it is
important to consider new approaches to the problem. The limitations
of present methods of control as they appear at present should be
briefly stated: In much of the area where worming occurs, domestic
animals are not under close supervision of the livestock owners and it
is impractical to round up the animals at regular intervals. Even
though many ranchers employ riders to look after the animals throughout
the fly season, many infested animals escape detection. Animals
infested with worms will seek hiding places and in brushy areas
it is virtually impossible to locate all of them. Furthermore, wild
herds such as deer, rabbits, wild hogs, and other animals are constant
reservoirs for the parasite. Such infestations serve to maintain a
high population of flies.

Thus, it is apparent that a high degree of control for worms
cannot be expected utilizing present methods of control. Without
modification to force frequent and regular inspection of livestock
subject to worming attack there is little likelihood that major
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research. An over-all reduction of the incidence of infestations
among domestic and wild animals not under control by livestock men is
necessary. It is felt that some effective and practical method of
reducing the worming population in nature seems to offer the only
possibility of reducing this incidence.

Present Status of Knowledge on the Feasibility of Employing Attractants for Controlling Screwworms

On the basis of present knowledge it is believed that the most feasible approach to the screwworm problem along lines indicated is through the development of attractants.

It is recognized that attractants and traps have in general proved disappointing as efficient and practical methods of controlling insects. Notwithstanding this, it seems illogical to advance this line of reasoning as an argument against such an approach to the screwworm problem. A careful study of the information presently available on the biology and habits of the screwworm fly and the consideration of certain observations which have been made on screwworm fly attractants lead us to believe that there is ample justification for initiating studies on this problem with reasonable chances that the final result might be a satisfactory solution to the screwworm problem. Some of the reasons for this optimistic outlook are discussed below:

1. As previously stated, the screwworm is a true parasite and develops only on living animals. Although precise data are not available it is known that the number of insects in nature is relatively low. It has been estimated that at the low population levels such as occur during the winter and early spring months the number of flies developing each week would not average more than 10 per square mile and a figure of 2 per square mile may be more accurate. Even when the screwworm fly reaches high population levels it is doubtful if the number will exceed an average of several hundred per square mile. Thus, in the case of this fly we are concerned with a relatively low population.
2. The screwworm fly ranges over extensive areas. Again precise data are not available but certain flight range studies show that flies will disperse at least 10 miles. Migration studies in the spring and summer based on new wound infestations records in new areas indicate that the rate of dispersion may average 20 to 25 miles per week. Since flight is the only logical explanation for the usual method of dispersion each year, it is almost certain that the flies cover a wide area in their search for wounds to infest. Therefore, any efficient attractant widely employed would likely be available to a high percentage of the flies within a given area.
3. Careful studies on attractants for the screwworm fly have not been conducted, however, certain tests and observations mentioned below have been made which indicate that this line of research offers a promising approach to the problem.
 - a. Adult flies are attracted in considerable numbers to ordinary decomposing meats. Attraction to decomposing meat products or to animal carcasses is apparently entirely gustatory.

Present Status of Knowledge on the Feasibility of Applying Attractants for Sampling Insects

On the basis of present knowledge it is believed that the most feasible approach to the numerous problems along lines indicated is through the development of attractants.

It is recognized that attractants and traps have in general proved disappointing as efficient and practical methods of controlling insects. Notwithstanding this, it seems logical to advance this line of reasoning as an argument against such an approach to the pest control problem. A general study of the information presently available on the biology and habits of the pest insects and the correlation of certain attractants with these habits has been made by the author. It is believed that there is ample justification for initiating studies on this problem with reasonable chances that the final result might be a satisfactory solution to the pest control problem. Some of the reasons for this optimistic outlook are discussed below:

1. As previously stated, the pest insects are a true parasite and develop only on living animals. Although precise data are not available it is known that the number of insects in nature is relatively low. It has been estimated that at the low population levels such as occur during the winter and early spring months the number of flies developing each week would not average more than 10 per square mile and a figure of 2 per square mile may be more accurate. Even when the pest insects reach their high population levels it is doubtful if the number will exceed an average of several hundred per square mile. Thus, in the case of this fly we are concerned with a relatively low population.

2. The pest insects fly ranges over extensive areas. Again precise data are not available but certain flight range studies show that flies will disperse at least 10 miles. Migration studies in the spring and summer based on new wound infestation records in new areas indicate that the rate of dispersion may average 10 to 25 miles per week. Since this is the only logical explanation for the rapid method of dispersion each year, it is almost certain that the flies cover a wide area in their search for wounds to infest. Therefore, any efficient attractant widely employed would likely be available to a high percentage of the flies within a given area.

3. General studies on attractants for the pest insects have not been conducted, however, certain facts and observations mentioned below have been made which indicate that this line of research offers a promising approach to the problem.

a. Adult flies are attracted in considerable numbers to ordinary decomposing meats. Attraction to decomposing meat products or to animal carcasses is apparently entirely gustatory.

- b. Animal wounds contain the only factor in nature which is known to stimulate oviposition. This factor is apparently highly specific and produces a marked response in the gravid females.
 - c. Infested wounds are many times more attractive than are uninfested wounds.
 - d. The artificial medium on which larvae are reared in the laboratory at temperatures of 80° to 85° F. is relatively unattractive to gravid females.
 - e. The same medium when heated to 100° F. or above is highly attractive to gravid flies and they will readily oviposit on such a medium. Thus, the normal attractant or stimulative factor may be associated with animal heat.
 - f. The presence of larvae alone does not constitute an attraction in artificial media or in animal wounds but the decomposition products resulting directly or indirectly from their presence are highly attractive.
 - g. Animal tissues (lean meat or dried blood) are more attractive to gravid females when placed on animals than are the same tissues not associated with animals. Thus it has been demonstrated that the animal contributes to attraction, although this is certainly not the dominant factor.
4. Since wounds of animals contain the only reproductive attractant for screwworm flies in nature and since under laboratory conditions this type of attraction can be produced in artificial breeding media it seems that the development of attractants would offer promise. In nature the number of available wounds is a definite limiting factor to the number of screwworm infestations that can occur. Only a small percentage of animals possess wounds at any given time, therefore, any efficient attractant could, no doubt, be utilized as "artificial" wounds on animals in numbers which would far exceed the number of natural wounds. The utilization of artificial wounds in ratios of perhaps 50 artificial to 1 natural wound might in a period of several weeks or months completely nullify the biotic potential of the flies in nature. It is recognized that the treatment of large numbers of animals would constitute a major undertaking but even if impractical as a routine method of control, it would certainly be feasible if such a method would achieve eradication of screwworms from isolated areas, such as the Southeast infestation. Efficient attractants might also be utilized in traps or in other ways that would eliminate the necessity for having to use animals in the control procedure.

Artificial attractants which might compete with natural wounds could conceivably be produced with ordinary blood or other animal

5. Animal wounds contain the only factor in nature which is known to stimulate oviposition. This factor is apparently highly specific and produces a marked response in the gravid females.

6. Infected wounds are many times more attractive than are uninfected wounds.

7. The artificial medium on which larvae are reared in the laboratory at temperatures of 80° to 85° F. is relatively unattractive to gravid females.

8. The same medium when heated to 100° F. or above is highly attractive to gravid flies and they will readily oviposit on such a medium. Thus, the normal attraction or stimulation factor may be associated with animal blood.

9. The presence of larval skins does not constitute an attraction in artificial media or in animal wounds but the decomposition products resulting directly or indirectly from their presence are highly attractive.

10. Animal tissues (lean meat or dried blood) are more attractive to gravid females when placed on animals than are the same tissues not associated with animals. Thus it has been demonstrated that the animal contributes to attraction, although this is certainly not the dominant factor.

11. Since wounds of animals contain the only reproductive attractant for sawworm flies in nature and since under laboratory conditions this type of attraction can be produced in artificial breeding media it seems that the development of attractants would offer promise. In nature the number of available wounds is a definite limiting factor to the number of sawworm infestations that can occur. Only a small percentage of animals possess wounds at any given time, therefore, any efficient attractant could, no doubt, be utilized as "artificial" wounds on animals in numbers which would far exceed the number of natural wounds. The utilization of artificial wounds in place of natural wounds 50 artificial to 1 natural wound might in a period of several weeks or months completely nullify the static potential of the flies in nature. It is recognized that the treatment of large numbers of animals would constitute a major undertaking but even if impractical as a routine method of control, it would certainly be feasible if such a method would achieve eradication of sawworms from isolated areas, such as the Southern Infestation. Efficient attractants might also be utilized in traps or in other ways that would eliminate the necessity for having to use animals in the control procedure.

Artificial attractants which might compete with natural wounds could conceivably be produced with ordinary blood or other animal

tissues if suitably formulated. Various proteins or synthetic organic compounds may also provide effective attractants that could be employed in various ways.

Brief Outline of Proposed Research on Attractants

It is realized that the study of attractants for screwworm flies will likely be an exceedingly complex problem. However, no careful fundamental studies on attractants have been undertaken in the past, primarily because efforts have been concentrated on other phases and because personnel trained in biochemistry and bacteriology have not been available for assignment to the problem. It is indicated that specialists will be required to develop the fundamental and basic information needed, and a research team consisting of an entomologist, biochemist, and bacteriologist is suggested.

It is firmly believed that the importance of screwworms and the indications that attractants might offer a satisfactory method of control, warrant the consideration of carefully planned research on the problem.

The following is a tentative list of the major line projects that would be considered in connection with a research project on screw-worm fly attractants:

1. Study of the bacterial flora and chemistry of infested wounds and artificial breeding media (including tests as attractants of various decomposition products that might be isolated).
2. Determine if factors or products attractive to screwworm flies are produced in media infested with various species of blow flies such as Lucilia, Phormia, Cochliomyia macellaria, Calliphora, and Sarcophaga.
3. Test various animal tissues, such as muscle, blood, glands, etc. to determine the relative attractiveness of their decomposition products to screwworm flies (both gravid and non-gravid flies).
4. Test various proteins such as cysteine, to determine their relative attractiveness to screwworm flies (both gravid and non-gravid flies).
5. Test various synthetic organic compounds in a search for synthetic attractants.
6. Test various insecticides which might be incorporated with attractants to destroy adults attracted thereto.

It is suggested that the study of attractants for sawfly larvae will likely be an exceedingly complex problem. However, no careful fundamental studies on attractants have been undertaken in the past, primarily because efforts have been concentrated on other phases and because personnel trained in biochemistry and bacteriology have not been available for assignment to the project. It is indicated that specialists will be required to develop the fundamental and basic information needed, and a research team consisting of an entomologist, biochemist, and bacteriologist is suggested.

Brief Outline of Proposed Research on Attractants

It is firmly believed that the importance of attractants and the indications that attractants might offer a satisfactory method of control, warrant the consideration of carefully planned research on the problem.

The following is a tentative list of the major line projects that would be considered in connection with a research project on sawfly attractants:

1. Study of the bacterial flora and chemistry of infected wounds and artificial breeding media (including tests as attractants of various decomposition products that might be isolated).

2. Determine if factors or products attractive to sawfly larvae are produced in media infected with various species of blow flies such as Lucilia, Phormia, Cochliomyia macellaria, Calliphora, and Sarcophaga.

3. Test various animal tissues, such as muscle, blood, glands, etc., to determine the relative attractiveness of their decomposition products to sawfly larvae (both gravid and non-gravid flies).

4. Test various proteins such as cytochrome, to determine their relative attractiveness to sawfly larvae (both gravid and non-gravid flies).

5. Test various synthetic organic compounds in a search for synthetic attractants.

6. Test various insecticides which might be incorporated with attractants to destroy adults attracted thereto.

7. Test various insecticides which might be incorporated with attractants to destroy adults attracted thereto.

Estimate of Personnel and Funds Required to Undertake
Investigations on Screwworm Fly Attractants

P-4	Entomologist.....	\$ 5,000.00
P-4	Physiological Chemist or Biochemist.....	5,000.00
P-2	Bacteriologist.....	3,300.00
SP-5	Technicians - 3 @ \$2300.....	7,500.00
CAF-3		2,100.00
	Equipment, supplies, chemicals, transportation, animals, and general operating expenses.....	<u>5,000.00</u>
		\$ 27,900.00

Location

If approved, the research would be carried out at the Kerrville, Texas, laboratory, under the direction of Dr. E. W. Laake. Adequate laboratory space and facilities with the exception of specialized equipment are available. The laboratory maintains a colony of the screwworm and laboratory animals as well as livestock are available. In addition Kerrville is within the area where screwworms are prevalent in nature and naturally infested animals can be obtained for study.

Duration

The time required to carry out the research project cannot be estimated with any degree of accuracy, however, basic studies should be undertaken on all aspects of the problem. A period of 3 years is suggested as the minimum period of time.

Cooperation

None during early stages of investigations.

Estimate of Personnel and Funds Required to Undertake Investigations on Insect-borne Typhus

Entomologist.....	5,000.00	1-4
Physiologist or Chemist.....	5,000.00	1-4
Bacteriologist.....	5,000.00	1-4
Technicians - 3 @ \$2500.....	7,500.00	1-4
.....	2,100.00	1-4
Equipment, supplies, chemicals, transportation, animals, and general operating expenses.....	5,000.00	1-4
	<u>27,600.00</u>	

Location

If approved, the research would be carried out at the Kertville, Texas, laboratory, under the direction of Dr. E. W. Beck. Adequate laboratory space and facilities with the exception of specialized equipment are available. The laboratory maintains a colony of the guinea pig and laboratory animals as well as livestock are available. In addition Kertville is within the area where screwworms are prevalent in nature and naturally infested animals can be obtained for study.

Personnel

The time required to carry out the research project cannot be estimated with any degree of accuracy, however, basic studies should be undertaken on all aspects of the problem. A period of 3 years is suggested as the minimum period of time.

Cooperation

From during early stages of investigations.